lead image by Diane Fleischer

Wartime Construction PROJECT OUTCOMES as a Function of CONTRACT TYPE

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The United States has spent more than $23 billion on construction in Afghanistan since 2001. The dynamic security situation created substantial project uncertainty, and many construction projects used cost-plus-fixed-fee contracts (CPFF) instead of the firm-fixed-price (FFP) norm. Using a dataset of 25 wartime construction projects managed by the Air Force Civil Engineer Center, the authors sought to confirm that both contract types yield project outcomes consistent with the established literature. As expected, they found CPFF contracts had greater cost and schedule growth than FFP. However, they did not find differences regarding as-built quality. Additionally, the authors sought to determine whether CPFF contracts exhibited greater construction risks than FFP contracts. They found no significant differences between contract types in terms of security incidents or other environmental factors. This research may be particularly relevant to military owners who contract projects in wartime environments.

Keywords: *firm-fixed-price, cost-plus-fixed-fee, Afghanistan, construction management, contract structure*

Background

Contracts should allocate risk to the contracting party best able to manage the risk. According to McInnis (2001), risk in the construction industry has been categorized into two divisions: contractual risk and construction risk. Contractual risks include items such as miscommunication, lack of contract clarity, or poor contract administration. They are internal to the contract and occur because an imperfect owner and imperfect contractor have chosen to work together. Construction risk includes items such as weather, resource availability, and acts of God. In contrast to contractual risk, construction risk is external to the contracting parties and would exist even if the parties were perfect (McInnis, 2001). Risk allocation is especially important in a wartime construction environment. Contractors working on behalf of the U.S. mission in Afghanistan faced a host of risks, including security threats, long logistical chains, extreme weather, and a lack of qualified personnel (Recurring Problems in Afghan Construction, 2011). As the owner, the U.S. Government managed and allocated the risk through contract type choices. Using the lens of contract types employed in Afghanistan, namely fixed-price and cost-reimbursable contracts, this article seeks to understand better the differences in contractor behaviors across contract types in a wartime construction environment.

The default contract type for federal construction services is a firm-fixed-price (FFP) contract (Federal Acquisition Regulation [FAR], 2015, pt. 36.207). Contracting officers are responsible for contract type determinations, but they are aided by the FAR decision framework. Contracts with well-established specifications that allow both the government and prospective bidders to estimate costs accurately should be FFP contracts (FAR, 2015, pt. 16.104; Scherer, 1964); such contracts place the maximum amount of construction risk on the contractor and should also provide the contractor with higher profit expectations (Scherer, 1964). Construction contracts typically are reasonably well defined. Thus, FFP contracts should be used.

A cost-plus-fixed-fee (CPFF) contract is the opposite of an FFP contract. The government assumes all risk for allowable costs up to the extent prescribed in the contract (FAR, 2015, pts. 16.301–1). Under this contract type, the government and contractor agree to a fee that is fixed at the inception of the contract and based on an estimate of total costs rather than final costs (FAR, 2015, pt. 16.306). The estimate is not binding, and the true cost is flexible up to the allowed maximum amount (Scherer, 1964). Unless significant uncertainty or risk is involved in the project, CPFF contracts should not be used in federal procurement (FAR, 2015, pts. 16.301–2). Because the government bears the risk of the uncertain environment, these contracts have significantly weaker cost-efficiency incentives (Scherer, 1964); consequently, they are typically used only for preliminary and exploratory studies as a precursor to FFP contracts (FAR, 2015, pt. 16.306).

An incentive contract is a third type of contract that lies between the polar opposites of FFP and CPFF contracts. This contract type allows owners to reward contractors for meeting specific cost, delivery, or performance goals (Bower, Ashby, Gerald, & Smyk, 2002). According to the FAR (2015, pt. 16.401), incentive contracts may be used when FFP contracts are not feasible and the government needs options to motivate the contractor to improve delivery efficiency and minimize waste. The contract type allows owners to share risk more evenly with contractors. Incentive contracts have increased in popularity in the private construction sector (In't Veld & Peeters, 1989). Yet, their actual usage remains low in absolute terms. The literature suggests that owners will generally use either FFP or CPFF contracts for construction services (Bajari & Tadelis, 2001).

From 2002 to 2013, the United States spent more than $23 billion on wartime construction efforts in Afghanistan (Johnson, 2014, p. 2). Contractors building and repairing infrastructure and facilities on behalf of the U.S. Government faced a different and unique environment when compared to peacetime construction. This environment included Taliban attacks that killed or injured workers and destroyed equipment (Affleck, Seman, Deegan, Freeman, & Sargand, 2011; cf. *Tawazuh Commercial and Construction Co. Ltd. v. United States,* 2011), a remote and problematic supply chain (Boon, Huq, Lovelace, 2011; cf.

Water Reclaim Systems Inc. v. United States, 2008), and a harsh physical environment (Affleck et al., 2011). The environment was deemed sufficiently uncertain that the U.S. Government's contracting officers elected to use a combination of FFP and CPFF contracts to support U.S. construction requirements.

> ***While cost reimbursable contracts may entice companies to submit bids, they also provide a significant possibility for cost growth and will need to be monitored differently than fixed-price contracts.***

We seek to expand the body of knowledge regarding contract types in wartime construction. This research may be particularly relevant to military owners who contract construction projects in wartime environments. While cost reimbursable contracts may entice companies to submit bids, they also provide a significant possibility for cost growth and will need to be monitored differently than fixed-price contracts. Conversely, fixed-price contracts in wartime environments may shift so much risk on contractors that it is impossible for companies to make a profit, leading to higher prices due to a lack of competitive bids or a reduction in project quality. Therefore, this research effort used data from 25 Afghan wartime construction projects to search for factor differences between fixed-price and cost-reimbursable projects. These projects were funded by the U.S. Government in support of the NATO Training Mission-Afghanistan, with the Air Force Civil Engineer Center (AFCEC) serving as the construction agent (i.e., the entity responsible for contract administration, including quality assurance). While the Afghan government took ownership after contract close out, the U.S. Government was the owner during contract administration. We seek to answer two investigative questions in this study:

1. Do CPFF and FFP wartime construction contracts yield project outcomes consistent with the established (peacetime) literature?

2. Given that CPFF contracts should be used in uncertain circumstances, did CPFF contracts exhibit greater construction risks than FFP contracts?

Literature Review

The underlying theory of contract behavior based on contract types has been well established. The theory of contractual incentives promulgated by Sherer (1964) established expected contractor behaviors using a maximization problem. The theory focuses on expected contractor behaviors in incentive contracts (cf. Federal Acquisition Regulation, 2015, pt. 16.401) that lie between the polar choices of FFP and CPFF, yet it also informs our understanding of contractor behaviors in FFP and CPFF contracts. For all contract types, a contractor's profit, π_C, can be determined by using the following equation, where π_T equals the target profit amount, α equals the cost-sharing coefficient, C_T is the negotiated target cost, and C_A is the actual cost charged to the contract.

$$\pi_C = \pi_T + \alpha(C_T - C_A)$$

For FFP contracts α will equal one, and for CPFF contracts α will equal zero. Simplifying the equation, we see that a contractor's expected profit for FFP contracts is its negotiated target amount plus its bid price minus actual costs. In contrast, for CPFF contracts, a contractor's expected profit is only the negotiated target amount (which may increase through the negotiation of added work). Hence, it is widely known that there are weak cost-saving incentives for CPFF contracts.

The negotiated target amount, π_T, is a function of financial risk. When the contractor bears additional financial risk, such as in an FFP contract, the negotiated target amount will be higher. When the contractor has negligible risk, as in the case of CPFF, the target amount will be lower (Scherer, 1964).

Shearer's (1964) study notes several key contractor behaviors. First, for established projects, where the risk can be managed, contractors should prefer FFP contracts as they have higher potential profit margins for the contractor. Second, as project uncertainty increases, contractors prefer CPFF contracts over FFP, at the expense of higher profit margins; CPFF contracts shield contractors from potential losses due to the uncertainty. Last, because FFP contractors bear the risk for actual costs, C_A, if contractors encounter unexpected risk, actual costs can be reduced by cutting quality, letting the schedule slip, or eliminating personnel.

Bajari and Tadelis (2001) have proposed a complementary theory that views the contract-type decision in terms of postaward adaptability instead of preaward superior knowledge. They note that FFP contracts can reduce initial costs, but those cost savings can be lost through contract

modifications. Cost savings are lost because the FFP contract compensation scheme is based on specific delivery requirements agreed to within the contract. While the contract allows for changes, implementation of the changes requires the compensation to be renegotiated. In contrast, CPFF contracts have a well-defined compensation scheme for both the initial design and subsequent changes. Awarding a contract modification does not require renegotiation. The postaward adaptability also implies that less conflict (or friction) will be observed between the owner and the contractor with CPFF contracts. Uncertainty also plays a central theme in Bajari and Tadelis's model. For projects with little or no uncertainty, FFP contracts will be preferred; for projects with high uncertainty, CPFF contracts will be preferred. The model suggests that complex projects should be acquired using CPFF contracts to allow greater adaptability to the inherent design changes; in contrast, simpler projects should be acquired using FFP contracts to provide cost savings to the owner.

> ***The literature is clear that as project requirement uncertainty increases, owners should consider the use of cost-reimbursable contracts.***

The empirical evidence within the literature largely supports these two theories. FFP contracts should be used for well-defined projects and CPFF contracts for projects with more uncertainty (Adler & Scherer, 2011; In 't Veld & Peeters, 1989; Müller & Turner, 2005; von Branconi & Loch, 2004; Wamuziri, 2013). First, von Branconi and Loch (2004) and Müller and Turner (2005) discussed the term project uncertainty, i.e., the project's degree of risk, using the framework of owner involvement. Those authors observe that owners tend to be less involved during FFP construction, which can lead to perceived poor outcomes. Because the project requirement is expected to be well defined, an owner's failure to apply sufficient diligence in defining the requirement may lead to an outcome that does not meet quality expectations. Von Branconi and Loch (2004) and Müller and Turner (2005) also note that with CPFF contracts, the project is ill-defined by definition. The lack of definition compels the owner to be more involved, resulting in physical outcomes that typically meet expectations. As is often the case, if costs are not controlled, CPFF will have higher costs. Adler and Scherer (2011) view the uncertainty difference in terms of knowledge. If the contractor can apply superior knowledge in support of the contract requirements, CPFF contracts

are preferred; otherwise, FFP contracts should be used. Lastly, In 't Veld and Peeters (1989) examined which categories of construction uncertainty should sway the contract type decision. They found that FFP contracts were an appropriate mechanism for contractors to manage risk from resource availability, schedule criticality, and performance requirements. However, if the risk is due to cost uncertainty or technical uncertainty, cost-reimbursable contracts should be used. The literature is clear that as project requirement uncertainty increases, owners should consider the use of cost-reimbursable contracts

Scherer's theory as it relates to cost performance and quality has largely been substantiated in recent work investigating construction contracting. Wamuziri (2013) found that negotiated target amounts are indeed higher for FFP construction projects. Additionally, he found CPFF contracts to have higher overall costs. Jaszkowiak (2012) conducted the only wartime comparison of contract types that we were able to locate. She found that FFP contracts had less schedule growth, CPFF contracts produced better quality facilities, and there was no cost growth difference between the two. While the study had a small sample size, the results are generally consistent with previous literature, with the exception that she did not observe cost growth differences.

In summary, the literature suggests three primary performance differences between FFP and CPFF contracts. First, on average, FFP contracts will have less cost growth than CPFF contracts. Second, FFP contracts will have less schedule growth than CPFF contracts. Lastly, FFP contracts will be of lesser quality than CPFF contracts. These three factors—time, cost, and quality—form the project management iron triangle and are known to influence one another (Ika, 2009).

Given these performance outcomes as indicated by the literature, we next will discuss how wartime construction may differ from peacetime construction and suggest ways in which the performance differences may be affected. Wartime projects likely face the same risks as peacetime projects, with some notable additions. The U.S. Army Corps of Engineers (USACE) commissioned a study to document construction challenges in Afghanistan (Affleck et al., 2011). Many of the risks observed by the USACE are not unique to wartime—they are common in other nearby Asian and African countries and include design problems, planning problems, weather interference, unskilled workers/quality problems, difficulty working with the owner or lack of direction from the owner, and change orders or scope changes (Affleck et al., 2011; Assaf & Al-Hejji, 2006; Mansfield, Ugwu, & Doran, 1994; Marzouk & El-Rasas, 2014; Olima & K'akumu, 1999).

The Afghanistan Study found that security concerns were overwhelmingly the primary challenge to projects (Affleck et al., 2011). This factor is unique to wartime projects. However, the FAR contains provisions for security. It defines acts of God (weather) and acts of the public enemy (hostile or criminal acts) as excusable delays (FAR, 2015, pts. 52.249–14; Kelleher, Walters, Smith, Currie, & Hancock, 2009). Also, while not required by the FAR, it was common practice to require contractors to carry insurance to cover the loss of equipment stemming from criminal or hostile acts. Additionally, many contracts required contractors to provide their own security, because U.S. military and Afghan Security Forces did not provide active security for construction projects (*Tawazuh Commercial and Construction Co. Ltd. v. United States*, 2011). In the context of contract types and risk allocation, the contracts treated the security as a valid construction risk.

In assessing the resulting risk, arguments can be made for classifying a project as either an FFP or a CPFF contract. One argument for continuing to classify construction as FFP is that the project specifications do not change as a result of possible attacks. Technical uncertainty would remain the same (In 't Veld & Peeters, 1989). However, using the cost uncertainty argument (In 't Veld and Peeters, 1989), one could argue that security risks will cause

more cost uncertainty. Even when the company is insured against the loss of personnel or equipment, the cash needed to continue the project could be at risk while the claim is adjudicated. Without sufficient cash to continue material acquisition and payroll requirements, a project could be halted while it is made whole. Thus, it is reasonable to use a CPFF contract to cope with cost uncertainty.

The physical environment of the project is commonly mentioned in both wartime and peacetime literature. Weather conditions are one of the most commonly cited delay factors for all projects. Afghanistan has the potential for particularly harsh weather, especially in the mountainous regions. Affleck et al. (2011) stated that planning for harsh weather was particularly poor in Afghanistan. Other industry literature does not discuss planning, but does consistently cite weather as a cause for delay. Most construction contracts allow for a certain number of weather delay days, but also state that it is considered an excusable delay, offering no compensation except in extreme cases (Kelleher et al., 2009). As the literature notes, schedule criticality can be effectively managed with FFP contracts (in 't Veld & Peeters, 1989). Notwithstanding the harsh environment, there is no compelling argument for CPFF contracts instead of FFP contracts.

Methodology

To understand how contract types affect project outcomes (i.e., schedule, cost, or quality) in wartime construction projects, the Mann-Whitney median comparison test was used to test differences among the median for project factors and performance factors (Table 1). The project factors are basic metadata relating to cost and schedule performance for each project, such as award, contract length, and the number of contract modifications. Performance factors relate to quality performance: the major construction, design, and material quality control deficiencies cited by the quality assurance engineer, as well as worker health and safety compliance. Note that within Table 1, the performance factors are subdivided by major construction elements and represent observed deficiencies by government quality assurance (QA) engineers. As the FAR contains clauses to accommodate contingency construction, we expect to see project outcomes similar to those described by the literature.

TABLE 1. PERFORMANCE ANALYSIS FACTORS

Project Factors	
	Award Amount Final Cost Awarded Cost Growth (Index) Number of Contract Modifications Number of Change Orders (Scope Changes) Number of FPOP Extensions Total Days Added to the Contract Initial Period of Performance Final Period of Performance Awarded Schedule Growth (Index)
Performance Factors	
Quality Factors	Horizontal Work (concrete and/or asphalt) Building Foundation (concrete/rebar/soils) Electrical (high and low voltage, comm lines/outlets) Mechanical (HVAC, gas, boilers) Utility (water, sewer, and storm) Structural (masonry, steel, and wood) Interior Finishing (doors, tiles, walls, ceilings, bathroom fixtures, paint) Exterior Finishing (windows, exterior doors, garage doors, fences)
Technical Performance Factors	Design Performance Material/Submittals
Health and Safety	Safety Incidents and/or Deficiencies

The Mann-Whitney median comparison test was used to test differences among the median for uncertain environmental factors to determine whether FFP and CPFF contracts exhibited similar levels of external construction risks (Table 2). Environmental factors are the external elements of the physical setting that are outside the control of the contractor. Taliban attacks, severe weather, and interference from the Afghan government are examples of external environment factors. We expect that CPFF contracts should have more instances of security or weather challenges to account for the greater construction uncertainty.

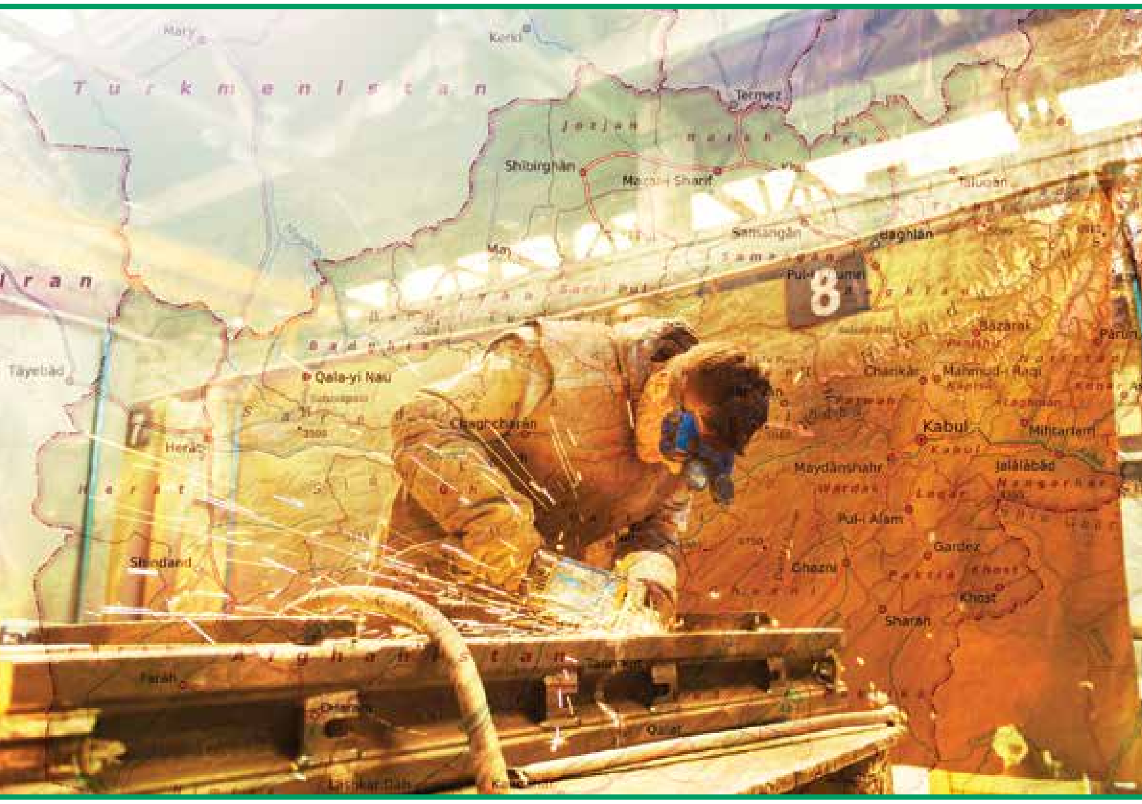
TABLE 2. RISK ANALYSIS FACTORS
External Environmental Factors
Region of Afghanistan
Security Incidents
Other External Environment Issues
Weather

The response variables were obtained by analyzing each project's daily reports, created by the U.S. Government's QA engineers. Twenty-five projects were analyzed: 11 were FFP, and 14 were CPFF. All projects were managed by AFCEC and were in support of the Afghan Government. Consequently, all projects were considered "outside-the-wire" (i.e., they occurred outside of the guarded perimeter of U.S. military operating locations). Each report contained comments regarding construction quality (positive and negative) as well as daily construction activities (e.g., quality deficiencies, mock-up meetings, progress for each craft). They also documented delays, security incidents, safety mishaps, or deficiencies. The average award cost was $25.5 million (median was $17.0 million), and the average final cost of the projects was $33.2 million (median was 23.9 million). The majority of the projects focused on vertical construction. Table 3 provides summary data regarding the projects.

TABLE 3. PROJECT DATA

Project Information	Mean	Median	Standard Deviation
Award Amount	$25.5 M	$17.0 M	$21.4 M
Final Cost	$33.2 M	$23.9 M	$28.7 M
Number of Contract Modifications	8.73	7	3.94
Change Orders (Scope Changes)	2.93	2	2.40
Initial Period of Performance (days)	382.76	365	144.82
Final Period of Performance (days)	822.84	741	353.70

The daily quality reports were coded by the factors shown in Tables 1 and 2, yielding the independent variables for this study. When an occurrence of a factor was encountered in the review of the daily reports, the incident was recorded. Each occurrence was independently linked to the project and all of the metadata associated with that project. This linkage allowed for a summary coding for each project, which then allowed for differentiation between projects, based on contract type.



Typically, two samples are compared for differences using a *t*-test; it calculates a mean and standard error based on a significance level for each sample. The standard errors are then compared to see whether the error bands overlap. If they overlap, one can conclude that there is no significant difference between the samples. The *t*-test requires the assumption of normally distributed data. Since our data did not meet this assumption, we used the Mann-Whitney test (also known as the Wilcoxon rank-sum test) to determine whether there were performance differences between the contract types. Conceptually, the main difference between a t-test and the Mann-Whitney test is the latter's use of relative values compared to observed values in a t-test. In the Mann-Whitney test, the observed values are converted to relative values by rank ordering them from 1 to n. A sum-rank score is then calculated that is then converted to a hypothesis test statistic, *U*, and used in a standard *z*-test (Gold, 2007).

If a *t*-test is used and its assumptions are violated, it can cause the analyst to draw incorrect conclusions. Consider the case in which the data are not normally distributed, but contain outliers to the right (i.e., final period

of performance with a mean of 823 days, a median of 741, and a standard deviation of 354). The increased variance from the outliers will increase the standard error and cause the error band to be larger. As error bands grow larger, statistical differences are more difficult to observe. Thus, one could infer there is no difference between the samples when there really is a difference. With the Mann-Whitney test, the influence of outliers is diminished because each observation is compared to other observations relatively; it is a more robust test than the t-test. When the data are normally distributed, the Mann-Whitney test has an asymptotic efficiency of approximately 95 percent when compared to a t-test (Lehmann, 2006).

Thus, the Mann-Whitney hypothesis test was used to determine whether the median values for each contract type were statistically different; its solution can indicate whether there is a significant difference in construction outcomes as measured by the average performance of an FFP contract over a CPFF contract. Its application is appropriate for our data, which are not normally distributed.

> ***Even more than security, the weather was the most commonly reported external environment issue, followed by security incidents, and then by any other external environmental issue, which ranged from locals and the Afghan National Army interfering with the project, to a swine flu outbreak halting progress on several projects for multiple days.***

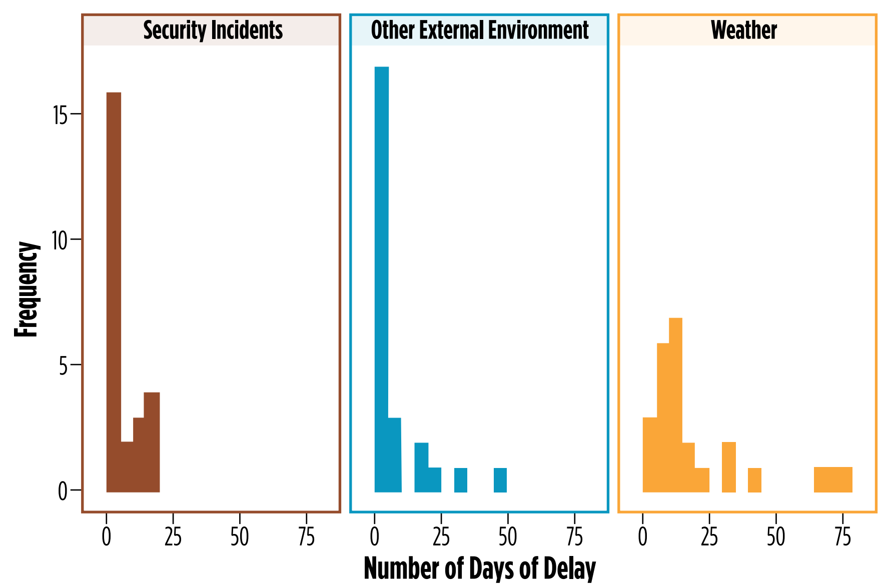
Analysis

All of the projects exhibited a significant amount of construction risk. Even more than security, the weather was the most commonly reported external environment issue, followed by security incidents, and then by any other external environmental issue, which ranged from locals and the Afghan National Army interfering with the project, to a swine flu outbreak halting progress on several projects for multiple days. Most projects had fewer than 40 days of weather delays. The maximum number of delay days due to security was 18. However, the majority of the projects had fewer than 6 days cited. A summary is shown in Table 4, and an accompanying histogram appears in Figure 1.

TABLE 4. EXTERNAL ENVIRONMENTAL FACTORS

Factor	Mean	Median	Standard Deviation
Weather (days lost)	20.32	12	21.95
Security Incidents (days lost)	5.32	3	6.08
Other External Environmental Issues (days lost)	6.60	1	11.70

FIGURE 1. EXTERNAL ENVIRONMENTAL DELAYS



Significant variance in the number of quality deficiencies was also noted among the projects. The most common performance problems were with the design and material submittals of a project. There were no recorded incidents of poor engineering that led to a failure. However, because the government had a thorough review process, the most commonly observed problem was contractors submitting finalized designs that did not address all the review comments, causing many unnecessary revision and resubmission cycles. The majority of projects had between 0 and 15 design performance incidents, and one project had 31. For material and submittal deficiencies, contractors were often late in submitting material submittals, and they also commonly ordered materials that did not coincide with the original submittal. However, most projects maintained an incident rate

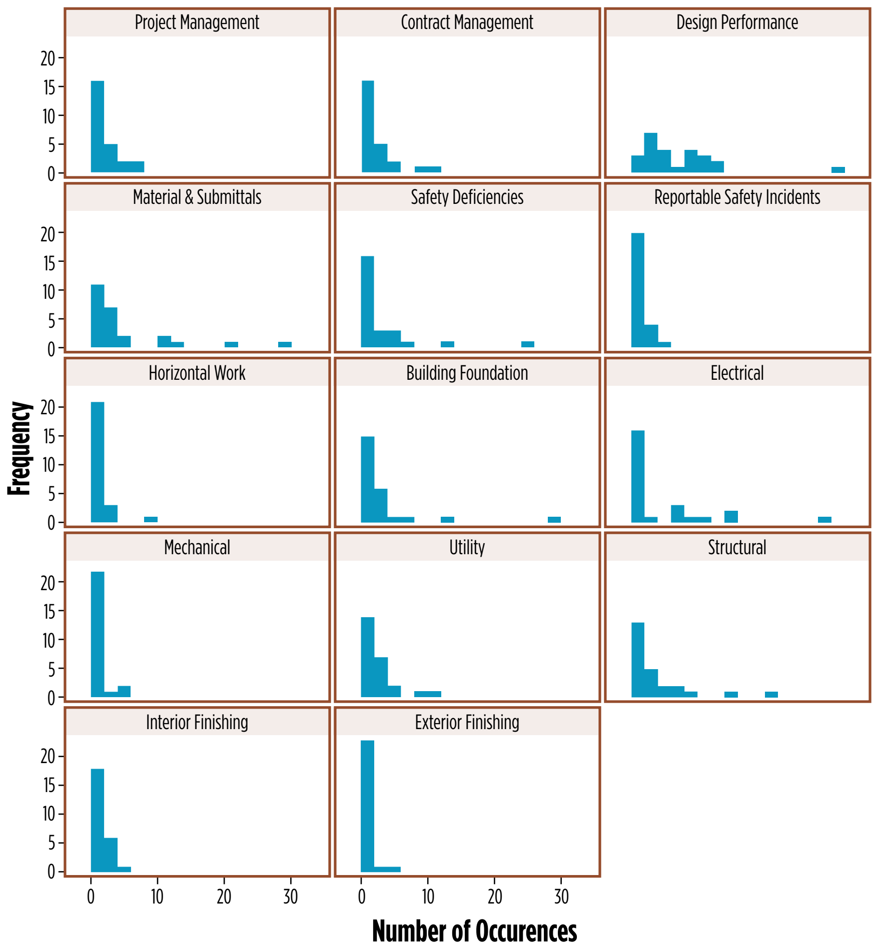
of five or less, with three projects being above that, and one as high as 24. The material submittal incidents were slightly more normally distributed (90 percent between 0 and 20), and the highest count was 28 incidents.

Of the eight quality factors, four had significant variance. The most common quality problem was Electrical work (both high and low voltage; M = 4.0, SD = 6.72). The project with the most Electrical problems had 28 recorded incidents. Structural issues were reported second most commonly (M = 3.0, SD = 4.85). The projects with the most Structural issues had 14 and 20 incidents respectively. Most projects did not have many Building Foundation problems (M = 2.7, SD = 5.8), but two projects had 12 and 28 each. Lastly, Utility issues (M = 1.7, SD = 2.72) had two outliers with 8 and 11 incidents. A summary of project performance is provided in Table 5, and an accompanying histogram is shown in Figure 2.

TABLE 5. PROJECT DEFICIENCY SUMMARY

Deficiencies (No. of Occurrences)	Mean	Median	Standard Deviation
Project Management	1.37	0	2.06
Contract Management	1.70	0	2.75
Design Performance	6.52	5	6.51
Material & Submittals	4.07	2	4.95
Safety Deficiencies	2.56	1	5.22
Reportable Safety Incidents	0.76	0	1.33
Horizontal Work	0.78	0	1.90
Building Foundation	2.70	1	5.77
Electrical	4.00	1	6.72
Mechanical	0.52	0	0.90
Utility	1.74	1	2.72
Structural	3.00	1	4.85
Interior Finishing	0.85	0	1.37
Exterior Finishing	0.48	0	0.56

FIGURE 2. CONSTRUCT DEFECTS



Results

The study used the Mann-Whitney pairwise comparison test with a 2-sided, normal approximation to test the research questions. The results, shown in Table 6, indicate that there are five significant factors and one near-significant factor that displayed differences across contract types. The *U* value is the rank assigned to the variable; the *z* is the test statistic value; and the "Sig. (2-tailed)" is the *p*-value for the test. Factors were determined

to be significant if they possessed a p-value of 0.05 or less. The Final Cost, Awarded Cost Growth, Final Period of Performance, Design Performance, and Contract Management were significant as a result of contract type.

TABLE 6. MANN-WHITNEY TEST FOR CONTRACT TYPES

Factor	Type	Mean	Standard Deviation	S	Z	Prob >|Z|
Award Amount	CPFF FFP	$25.6 M $25.3 M	$17.6 M $26.4 M	125	-0.96	0.338
Final Cost	CPFF FFP	$37.5 M $27.7	$28.6 M $29.1 M	105	-2.05	0.040*
Awarded Cost Growth	CPFF FFP	1.48 1.13	0.38 0.17	98	-2.44	0.015*
Number of Contract Modifications	CPFF FFP	10.1 7.4	4.8 1.8	124	-1.02	0.308
Change Orders	CPFF FFP	3.4 2.1	2.8 1.4	120	-1.26	0.208
Number of FPOP[1] Extensions	CPFF FFP	5.4 3.3	2.4 1.3	103.5	-2.17	0.030*
Total Days Added to Contract	CPFF FFP	591 330	275 151	97	-2.49	0.013*
Initial Period of Performance	CPFF FFP	390 373	145 145	138.5	-0.22	0.827
Final Period of Performance	CPFF FFP	945 668	400 209	105	-2.05	0.040*
Awarded Schedule Growth	CPFF FFP	2.46 1.86	0.77 0.61	107	-1.94	0.052[2]
Security Incidents	CPFF FFP	4.1 6.9	4.5 7.3	157	0.74	0.457
Other External Environmental Issues	CPFF FFP	5.4 8.2	8.9 14.4	151.5	0.45	0.653
Weather	CPFF FFP	22.9 17.1	22.4 2.1	126.5	-0.88	0.380
Project Management	CPFF FFP	1.3 1.6	2.1 2.2	154	0.63	0.526
Contract Management	CPFF FFP	1.2 2.6	2.8 2.7	180.5	2.15	0.031*
Design Performance	CPFF FFP	3.9 10.1	2.7 8.2	187	2.39	0.017*
Material & Submittals	CPFF FFP	6.1 2.3	8.5 3.7	119	-1.32	0.186

TABLE 6, CONTINUED						
Factor	**Type**	**Mean**	**Standard Deviation**	**S**	**Z**	**Prob >|Z|**
Safety Deficiencies	CPFF FFP	1.9 3.9	3.4 7.0	157.5	0.80	0.425
Reportable Safety Incidents	CPFF FFP	0.7 0.8	1.0 1.7	135	-0.48	0.631
Horizontal Work	CPFF FFP	0.6 1.2	0.9 2.8	140	-0.17	0.868
Building Foundation	CPFF FFP	2.1 4.0	3.2 8.1	151.5	0.45	0.652
Electrical	CPFF FFP	3.4 5.0	4.6 9.1	132.5	-0.58	0.561
Mechanical	CPFF FFP	0.5 0.6	1.2 1.2	152.5	0.62	0.531
Utility	CPFF FFP	1.7 2.1	2.9 2.6	150	0.37	0.709
Structural	CPFF FFP	3.2 3.4	5.3 4.5	149.5	0.33	0.738
Interior Finishing	CPFF FFP	0.6 1.3	1.0 1.7	156	0.77	0.438
Exterior finishing	CPFF FFP	0.6 0.5	1.2 0.5	151	0.48	0.628

Note.
*Signifies 2-tailed significance (p < 0.05). Reject null hypothesis.
[1]FPOP (Final Period of Performance)
[2]Nearly significant; and is significant using Fisher's Exact Test in a contingency table.

Final Cost for wartime projects was significantly lower for FFP contracts, as suggested by the literature. Likewise, Awarded Cost Growth was significantly lower for FFP contracts as well.

Final Period of Performance was lower for FFP contracts. The Awarded Schedule Growth Index was calculated by dividing the final government-allowed period of performance by initial contractual period of performance (not necessarily the actual performance period). The actual period of performance could not be used to calculate a schedule growth factor because of the inherent differences between fixed-price and reimbursable contracts. Fixed-price projects are contractually able to continue in operation after the contractual completion date has expired because the contractor is responsible for the risk. However, reimbursable contracts must be closed out when the period of performance expires unless the owner extends the

contractual completion date. Therefore, in a reimbursable contract, the actual completion date is always the same or before the contractual date. Consequently, actual completion dates are incomparable between the contract types. Thus, projects were compared using the contractual completion date. Moreover, the contractual completion date is within the control of the owner (whereas actual completion in fixed contracts is not) and is thereby a superior factor to compare between the two contract types. The Awarded Schedule Growth was a near-significant factor in the Mann-Whitney test. Therefore, further investigation was appropriate. A contingency table using Fisher's exact test revealed that Awarded Schedule Growth depended on contract type ($p = 0.0154$).

The FFP contracts performed worse than CPFF contracts in terms of Design Performance and Contract Management, but not in as-built work. Contract Management was defined as the contractor's ability to fulfill the administrative requirements of the contract. Common deficiencies included missed schedule or status updates, or provision of adequate living and working conditions for the QA engineers. This finding suggests that while contractual requirements were not always met with FFP contracts, the finished facility was comparable to facilities constructed with CPFF contracts.

Project Management deficiencies were a separate construct than Contract Management, and significant differences were not found between contract types. Our definition of Project Management mirrors closely what Pinto and Winch (2016) describe as project delivery activities: planning, execution, controlling, and close-out. Examples of Project Management deficiencies included proceeding with work without approval or scheduling conflicting craft disciplines in the same work area, resulting in delays and worker conflicts. No Project Management differences were found between contract types.

Design Performance was carefully defined so that these issues did not overlap with Project or Contract Management. Therefore, these issues only included design quality and design schedule performance. Although the construction agent has identified several design flaws postcontract completion, no occurrences of construction failure were recorded as a result of poor design. The most frequently observed Design Performance deficiency was late design submissions, and the responses to these issues were different across contract types. These late submissions caused FFP contractors to work at risk. Working at risk occurs when designs are not approved by the owner and the contractor decides to continue with construction, knowing rework may occur if the design changes before it is approved. This rework

is not compensated by the owner. The results suggested that FFP contractors were willing to accept this risk to stay on schedule and to avoid contractual penalties. On the other hand, the CPFF contractors did not have as many instances of Design Performance deficiencies. This significant difference suggests that the contractors were likely not motivated to work at risk because fixed profits were guaranteed and they did not fear the accompanying schedule growth.

> ***Reimbursable contracts were found to have significantly higher costs than fixed price contracts. This difference was found for cost increases during the life of the project and the final project cost.***

Discussion

Cost

Reimbursable contracts were found to have significantly higher costs than fixed price contracts. This difference was found for cost increases during the life of the project and the final project cost. Notably, there was not a significant difference in Award Amount between contract types. These findings demonstrate that reimbursable contracts are likely to be awarded at similar prices to FFP contracts, but are likely to cost more at the end of the project. The validity of this conclusion is strengthened by the significant difference seen in cost growth. In the analysis, large projects were compared alongside small projects; and there may have been considerable variance between the project factors, which may reduce the credibility of a direct comparison in terms of raw cost or some other attribute. The Awarded Cost Growth Index standardizes the projects' cost comparisons. For example, larger projects may have differences in risk and nature of work than smaller projects. Additionally, when a larger project experiences delay, it ought to cost more money to make up the time deficit. The Awarded Cost Growth Index removes unique assignments of cost to enable comparisons. When this was done, we found that the ratio between final and initial costs is significantly higher for reimbursable contracts versus fixed-price contracts. Higher cost growth in reimbursable construction contracts aligns with other industry research. Reimbursable contracts do not incentivize cost control (Nkuah, 2006); rather they may incentivize cost growth (Wamuziri, 2013). Thus, as expected, wartime construction contracts exhibited the same cost behavior as peacetime contracts.

Schedule

The average time required to complete a wartime reimbursable project is greater than the time for a fixed-price project. This is consistent with peacetime findings and confirms Jaszkowiak's (2012) results for other Afghan and Iraq U.S. military construction projects. The observed Awarded Schedule Growth is expected because structurally speaking, schedule and cost growth are strongly linked in reimbursable contracts. Whether funding becomes exhausted due to slow progress or unanticipated cost overruns, government contracting personnel are limited in their options for reimbursable contracts (assuming all costs have been legitimized during invoice auditing). To continue the project, they must provide additional funding, reduce the project scope, or terminate the contract in its current state (FAR, 2015, pts. 52.232–22). Based on this structural connection, we would expect contract modifications to be a mediating variable. Indeed, previous research has shown that contract changes are closely related to schedule performance in projects (Ibbs, 2011). While total number of Scope Changes was not different between the contract types, reimbursable contracts had more schedule modifications than fixed contracts. Additionally, the Total Days Added to the Contract was also higher for reimbursable contracts. Therefore, the results suggest that, rather than Scope Changes being the cause of Awarded Schedule Growth, as Ibbs (2011) suggested, it may be some other mediating factor (or possibly the contractor's lack of incentive to adhere to the schedule) that begets more Awarded Schedule Growth in reimbursable contracts.

Contract types also had a near-significant p-value for differences in the Awarded Schedule Growth Index. The p-value was so close to 0.05 (unlike any other factor) that additional analysis was performed for the factor. A contingency table showed that Awarded Schedule Growth could be dependent on contract type. Reimbursable contracts had higher Awarded Schedule Growth than fixed contracts. This reflects similar behavior as discussed with Final Cost: contractors for reimbursable contracts may not be motivated to control Awarded Schedule Growth (Nkuah, 2006). FFP contractors are incentivized to minimize construction costs and schedule, which involves indirect costs as the project is delayed. CPFF contractors do not have these inhibitions for either cost or schedule. The construction agent reported that contractors would often divide their original bid by the number of days in the period of performance to establish a daily burn rate. Often, the daily burn rate was maintained or exceeded. But just as often, the planned schedule was not met, and the allocated funds were exhausted before the project was complete. Therefore, when more time was granted to the project, additional funding had to be granted to complete the same project (L. Schoenenberger, personal communication, 2014). By design, CPFF projects have greater potential for Awarded Schedule Growth, and this research found that for this sample, on average they did exhibit more Awarded Schedule Growth, confirming previous literature.

Quality

Fixed-price contracts underperformed compared to reimbursable contracts in Design Performance and Contract Management. The daily reports indicated that the majority of the reported design deficiencies were due to incomplete design submissions to the government. The incomplete designs created a rework/resubmission cycle. The contractors would choose to work at risk on the projects (sometimes for months)—beginning construction without final, approved designs—in order to meet contractual performance obligations. Similarly, the contractors frequently worked at risk as they tried to comply with contract management tasks. Contractors would miss submission deadlines and would have difficulty correcting the deficiency. However, the daily reports did not indicate that project quality was directly affected as a result of contractors working at risk. Acceptable designs or contract submissions were eventually submitted. The tests suggest that contractors did not pay as close attention to contract and design documents on fixed-price contracts. It is interesting that projects were able to continue successfully in spite of severely late design submissions and approvals. This may confirm previous research suggesting there are unnecessary steps in

the government design-review process, or that some details of design are not critical to project completion and simpler criteria may still yield a successful project (Blomberg, Cotellesso, Sitzabee, & Thal, 2013).

This study found no significant difference in quality performance between the two contract types. This conflicts with the peacetime expected outcome of quality differences. As there is a relationship between time, cost, and quality, perhaps the differences are manifest only in the observed time and cost growth. Our results also contrast with Jaszkowiak's (2012) work. Her survey of construction professionals found that a reimbursable project tended to yield better quality projects. This research did not find any craftsmanship quality differences between fixed price and reimbursable projects. These conflicting results may be attributable to the source of data. Jaszkowiak (2012) assessed overall perceptions from the government construction management teams, whereas this study's data consist of QA deficiency reports. This research did not analyze customer satisfaction of the project, which is a large consideration in determining the final quality of a project (Baccarini, 1999; Lim and Mohamed, 1999). Notwithstanding, this research suggests that heightened deficiencies or poor quality work should not be a unique subject of focus for either contract type.

Security and the Environment

Reimbursable contracts are used in Afghanistan by the U.S. Government because of the increased risk due to the security situation. As a result, it was expected that external environmental factors would be more prevalent on reimbursable contracts. The use of this contract type is justified because of the more austere or uncertain project environments. However, there was no significant difference in delays due to any of the external environmental factors. In fact, security incidents and other external environmental delays (e.g., local interference) were reported more often in fixed-price contracts though not significantly. This result may suggest that risk assessments may not adequately assess the security situation for both reimbursable and fixed-price projects. Additionally, the term 'high risk' has a broad meaning. A project may have been high risk simply due to being in a remote location or

due to the security situation. Additionally, some accessible projects are classified as high risk because of the undefined scope, or anticipation of many change orders as the end-user firmed up requirements (L. Schoenenberger, personal communication, 2014). As the external environment was not a significant factor between contract types, these findings may also suggest that the high-risk projects are characterized more by vague project requirements than by the environment.

Limitations and Conclusions

Limitations

This study was limited to 25 projects, which restricted the statistical tests to nonparametric tests for the analysis. Future research should obtain a larger sample group, which will increase the number of analysis options. Another limitation was the depth of data retrieval from the daily reports. The combined length of the daily reports was approximately 20,000 pages. Therefore, only major deficiencies were analyzed. However, there were many other minor incidents recorded by the QA engineers. In-depth case study research on smaller groups of these projects may provide further insight into performance differences between contracts.

Conclusions

The purpose of this research is to provide construction agents, firms, and military leaders alike with information that will aid strategic decisions regarding future military construction and nation-building projects. All of these facts underline the rapidly changing environment that is wartime construction, which has a significant effect on the progress of a project. The results largely confirm that which has been known for decades. FFP contracts achieve lower cost and schedule growth than CPFF contracts. Additionally, we found similar external risk profiles for both types of contracts. Both contract types faced similar austere conditions in terms of physical attacks and a harsh environment. Nevertheless, it would be irresponsible to assume that FFP contracts are more advantageous for the government to use in a wartime environment. There were specific reasons, usually risk-oriented, that led the construction agent to use CPFF contracts, especially in the initial stages of the Afghanistan reconstruction. Arguably, the use of CPFF may have prevented the default of contractors on more high-risk projects. Instead, the message of this article is that owners need to be aware that reimbursable projects are likely to have more cost and schedule growth. Owners and their agents need to take proactive steps to minimize the growth and to reduce construction inefficiencies.

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